# 6.2

# In Situ Training Project: LMLSTP Phase III Report

**Barbara Woolford, Cynthia Hudy, Mihriban Whitmore, Ph.D., Andrea Berman, Jim Maida, Ph.D., Abhilash Pandya**

## INTRODUCTION

*Objectives of Experiment*

Long-duration space flight will require crewmembers to perform tasks they were not specifically trained for prior to flight. The length of the missions, on the International Space Station (ISS) or on future exploration missions, will prohibit detailed training in every possible activity and for every possible contingency. To ensure crew safety and productivity, efficient methods of providing rapid training without ground support are required.

Various forms of computer-based training are the best solution to this problem. The training material can be stored on CD-ROM, enabling shelves of manuals and drawings to be stored in a few cubic inches. Computers will be readily available on the spacecraft for a multitude of purposes. The status of computer-based training (CBT) using multimedia is far enough advanced that commercial authoring tools are available to enable nonprogrammers to create lessons rapidly, with multiple links to audio, video, drawings, and text.

The purpose of this study, carried out in the 20' chamber, was to evaluate the usefulness of specific features of multimedia training, including a two-dimensional task simulation.

*History of Project*

In the Phase IIa test, multimedia training was compared with two-way audio/video communication, which is similar to current methods of mission controllers talking a crewmember through a procedure. In that study, it was found that if the task only needed to be done once, the subjects preferred being "talked through" the task, and performed it in shorter time periods. However, comments during the debriefing indicated that the crew felt they would retain very little of the training received that way, compared to training learned from multimedia.

## METHODS/OBJECTIVES

*List and Description of Methods and Protocols*

The protocol required each volunteer to be trained on two tasks. One task was primarily a physical task: assembling a Graphical Retrieval and Information Display (GRiD) computer from its components. The other was primarily cognitive/perceptual: operating a relatively complicated instrument called a ScopeMeter, which combines features of a multimeter and an oscilloscope. The training material was presented as material organized in a Web page manner.

The independent variables were task type (physical vs. cognitive) and multimedia (MM) training type (self-test (Enhanced MM) vs. no self-test (MM)) in the training. The dependent variables were time to perform the task, number of errors, number of times features were revisited, and subjective ratings of the usefulness of features of the training material. The subjects were videotaped while performing the task to enable later review of task performance.

A total of four subjects voluntarily participated in this in-chamber demonstration project. These participants were the LMLSTP Phase III chamber crew. Of the four participants, two rated themselves as expert Windows 95® and World Wide Web users and two said they were intermediate-to-novice users.

Prechamber: The participants were brought into the Usability Testing and Analysis Facility (UTAF) at Johnson Space Center for prechamber training. They were familiarized with the use of the Web-based multimedia application. The multimedia application was similar to the version used during the actual project sessions, in that it showed text instructions, photographs, diagrams, and video. Due to time constraints on software development, however, the prechamber training did not include a prototype of the interactive self-test. Furthermore, the participants were not shown any of the task hardware to be used during the sessions so as to not confound the in situ training process.

In-chamber: While in the chamber, each subject participated in two sessions scheduled a minimum of two weeks apart. Each session was performed in two phases: participants trained on a task and then performed the task without referring to the training materials. Participants were given two hours to complete both the training and task. During the test sessions, the test conductor was present in the viewing room; however, the crew was encouraged to perform the task using only the multimedia application provided in the chamber. They were advised to ask questions regarding the use of the training application only, not the task itself.

For each of the training sessions, participants were provided with introductory text, which explained the nature of the task to be performed and reminded them how to use the training software. Participants were instructed to view whichever multimedia features they preferred, in whatever order they preferred, and as often as they wanted. In the Enhanced MM session, participants were instructed to access the interactive self-test once they felt that the task had been learned completely through viewing the other multimedia features.

The tasks and multimedia training types were counterbalanced across participants. For three of four participants, training for one session was with MM and the other was with the Enhanced MM. The fourth participant inadvertently skipped the self-test, and thus performed both training sessions with MM.

After each training/task combination, participants completed questionnaires which examined the usability and acceptability of each training technique and its available features. In addition, a comprehensive questionnaire concerning the comparison of different techniques for different tasks, as well as the background knowledge of each participant, was administered upon completion of all the sessions. Finally, participants were invited to individual debriefing sessions with the test conductors to understand the background of this demonstration, as well as to provide any other comments that they had about the training methods or tasks.

Postchamber: It was discovered that two crewmembers had participated in audio-visual communication for an unplanned chamber maintenance procedure. This provided an unexpected opportunity for comparison of the multimedia training with an actual real-time training situation performed with audio-visual communications but no prepared training materials. These two crewmembers provided comments comparing and contrasting the training in this experiment with the real-world case.

*List and Description of Hardware Used*

An IBM ThinkPad 755CX laptop computer with an Internet connection (to access a local server) was used for all sessions. Netscape 3.0® for Windows 95® was installed on the ThinkPad in order to view the training applications. QuickTime and Macromedia Shockwave plug-ins were installed within Netscape® to allow the video clips and self-tests to be accessed and viewed.

The multimedia training applications were interactive, button-driven World Wide Web sites developed in HyperText Markup Language (HTML) and JavaScript. The World Wide Web format was used to present the multimedia applications since the experimenters were experienced in Web development and because the training software had the ability to track usage statistics through the server log (such as which multimedia features were accessed, the order of access, and the time spent on each feature).

The multimedia included text procedures, shortened text procedures called "cue cards," video clips, diagrams, photos, and software help. The Enhanced multimedia included all features, plus the addition of an interactive self-test, which asked the participant to perform the task "virtually" on the computer screen using the mouse to manipulate the task objects. The Enhanced multimedia self-test was developed in Macromedia Director.

To allow participants to view multimedia features while reading the text procedures, each training application consisted of a screen divided into three parts:

1) a series of buttons and pull-down menus that led to training materials;
2) a multimedia feature window; and
3) a procedure window.

An illustration of the screen layout and available features is shown in Figure 6.2-1.

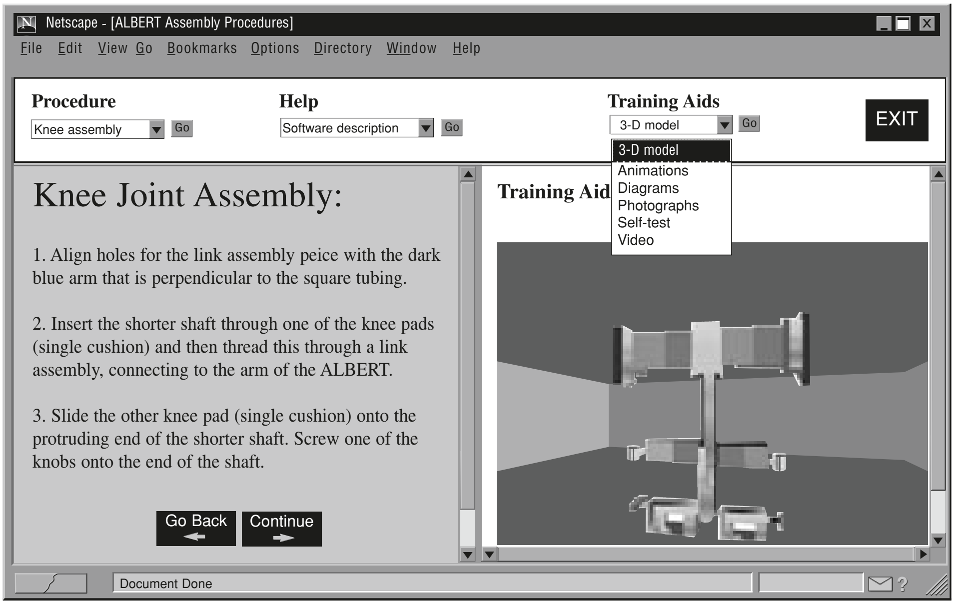


***Figure 6.2-1*** *Sample screen for the multimedia training material*

The two test objects – the GRiD computer and the ScopeMeter – are shown in Figures 6.2-2 and 6.2-3. The chamber crewmembers did not have any previous experience or training with these items or tasks. They were selected to provide “novel” but realistic tasks that might be performed in space flight. The GRiD laptop computer had served as a Payload and General Support Computer (PGSC) on the Shuttle. The participants received the computer disassembled and were tasked with assembling various components and connections. The Fluke ScopeMeter is a versatile device which can function as an oscilloscope as well as a meter for various scientific readings (voltage, current, etc.). The device consists of the ScopeMeter unit itself, a power supply, and two probes. The crewmembers were tasked with performing a specific set of procedures, using the ScopeMeter and accessories, to take a voltage self-diagnostic.

The task performance was observed and recorded using the video camera loca ed on the ground floor of the 20’ chamber. This camera was permanently available throughout the 91-day test and was not unique to this experiment.

RESULTS

*List of Pre-, In-, and Postchamber Anomalies*

Prechamber anomalies:

None - all subjects participated in training sessions.

In-Chamber anomalies:

1. One subject forgot to utilize the self-test option when it was available.
2. One test session was interrupted temporarily.

Postchamber anomalies: No anomalies, but two subjects participated in an additional debrief.

***Figure 6.2-2*** *The GRiD computer. The left photo shows the assembled computer. The right shows a stage midway through the assembly*

*Table of Method/Protocol*

Table 6.2-1 shows the planned protocol. Although one subject failed to use the self-test option when it was present, this table shows the number of subjects in each of the four conditions.

***Table 6.2-1*** *Protocol for Testing*

| | GRiD (physical) | ScopeMeter (cognitive) |
|---|---|---|
| Enhanced MM (Self-Test) | 2 | 2 |
| MM (no Self-Test) | 2 | 2 |

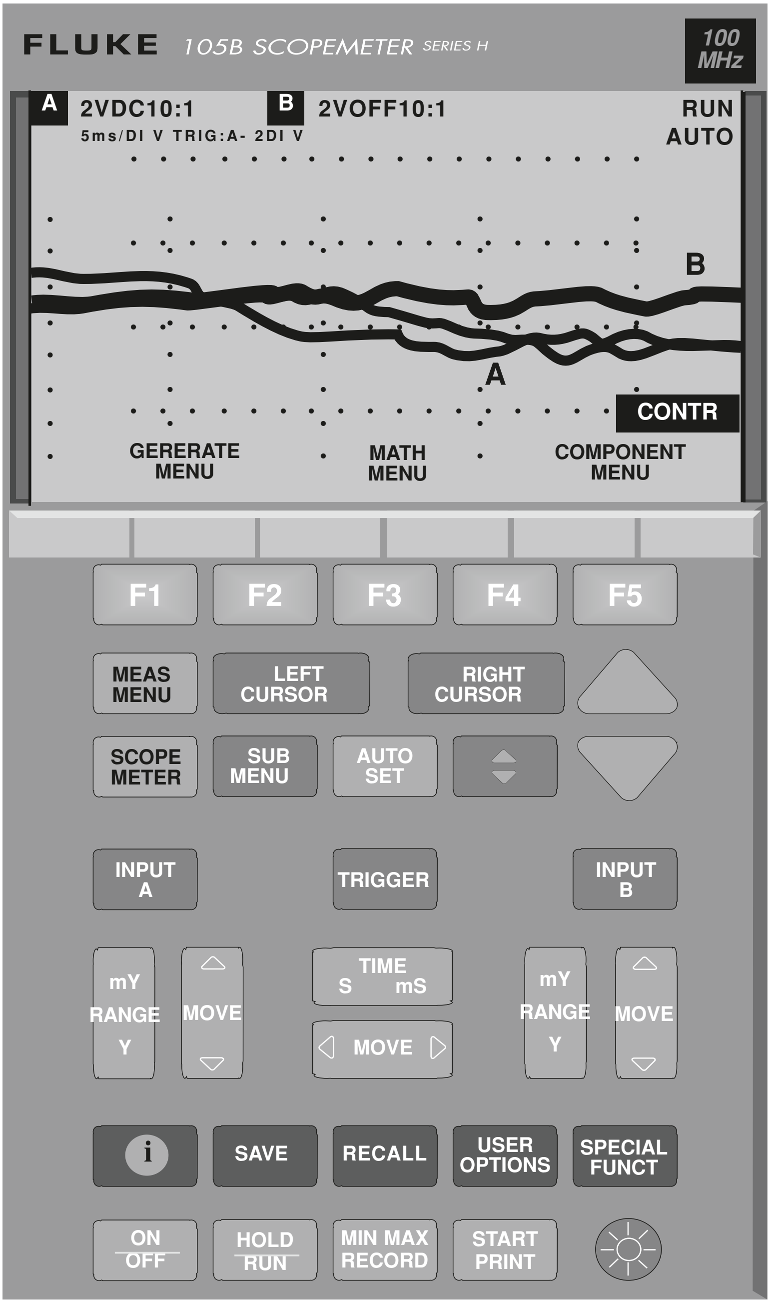


***Figure 6.2-3*** *The Fluke ScopeMeter, an electrical diagnostic instrument*

*Completeness/Quality of Data*

With only four subjects, this study by itself does not provide enough data for a robust statistical analysis. However, the usage data collected from the server and subjective debrief comments were very useful in confirming related studies and in refining the procedures for a larger laboratory study comparing virtual reality (VR) and multimedia for remote training.

*Objective Results*

There was remarkably little between-subject variation in time and number of errors for each of the two tasks. Time to complete the task (not including the time spent in training) was a dependent measure of great interest. Although the two tasks had approximately the same number of steps, the ScopeMeter task was performed much more quickly than the GRiD assembly. This is probably a result of the nature of the task: the GRiD assembly required many more types of physical operations, while the ScopeMeter task primarily required pushing keys and verifying information on the display.

ScopeMeter task times ranged from 3 to 4 minutes and did not seem to depend on the type of multimedia training received. GRiD task times (not including training) ranged from 15 to 27.5 minutes (see Table 6.2-2). Task times for the GRiD also did not depend on whether the subject had the self-test (Enhanced MM) or not. Analysis of the video data revealed that the task time for Subject 3 was not due to a deficiency in training, but rather a difficulty in performing some of the task steps (i.e., tucking cables in so the cover could close completely).

The second objective measure of interest was number of errors while performing the tasks. The subjects were not allowed to refer to the training material during the task performance, and did not have any type of cue cards or procedures to serve as memory aids. No errors were observed during performance of the ScopeMeter

***Table 6.2-2*** *Time (in minutes) to complete the GRiD assembly (physical) task for the MM and Enhanced MM training*

| Subject Number* | Multimedia | Enhanced Multimedia |
|---|---|---|
| S1 | | 15 |
| S2 | 15 | |
| S3 | | 27.5 |
| S4 | 18 | |

*NOTE: These subject numbers are not the same numbers assigned to the chamber crew in other studies task. The camera view recorded during task performance was optimized to provide as close a view as possible of the subject's activities. Due to the small size of the ScopeMeter display, it was not possible to track performance of each step of that task. However, all four subjects reported correct delta-voltage readings to the test conductor at task completion and therefore were able to correct any errors they may have committed prior to finishing the task. Two subjects made errors during GRiD assembly: one subject made two errors, and the other made three errors. None of the errors were committed by more than one subject. The number of errors made did not depend on training type. However, it should be noted that the subject who made three errors was distracted during the GRiD assembly and took a short break, which may have contributed to the number of errors committed.

The third set of objective data collected was the frequency with which the different multimedia features were used. This data was automatically captured by the Web site software. A majority of the participants browsed through each of the multimedia features at least once during their training, rather than focusing on one or two features in particular. For both the GRiD and the ScopeMeter tasks, the animation/video clips were the most, photos were second, and diagrams were third (see Figure 6.2-4).

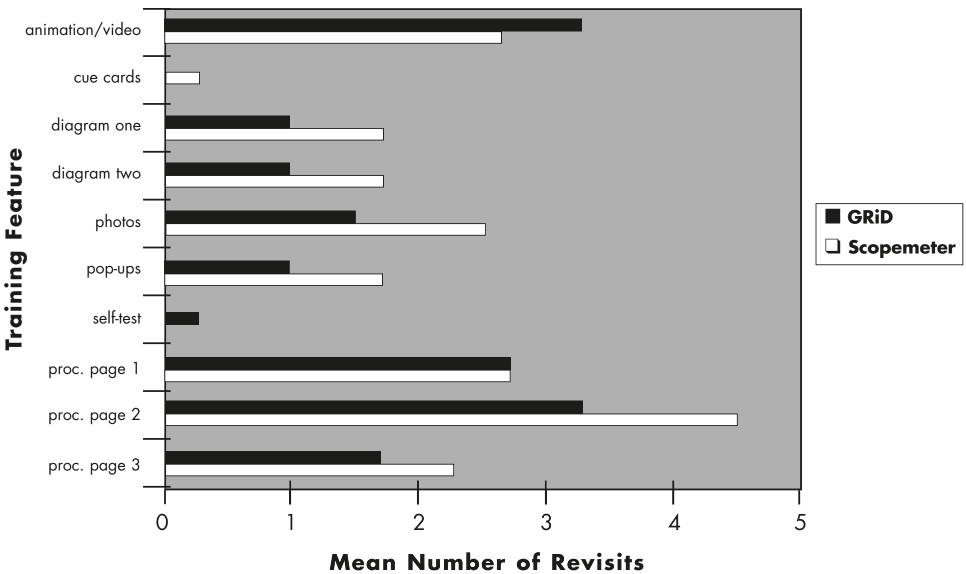


***Figure 6.2-4** Mean number of revisits to each of the multimedia features and each of the three procedure pages*

## SUBJECTIVE RESULTS

The general categories investigated in the subjective questionnaires included:

- Usefulness of the various multimedia features, including the self-test
- Ease of navigation (between and within pages and multimedia features)

- Proficiency with Windows 95® and World Wide Web browsing
- Acceptability of training (i.e., amount of information provided and difficulty level)

All questions were posed with a 7-point Likert scale. For most questions, a response of 7 meant that the subject found no shortcomings on that specific item. However, for some questions, a middle rating of 4 meant that the subject rated that issue "Just Right," in between the two extremes of "Too Long" and "Too Short" or "Too Much Information" and "Too Little Information."

Figures 6.2-5 and 6.2-6 show the questionnaire ratings for each task. For those questions where 7 represented a response of "Completely Acceptable," such as the usefulness of the various multimedia features, the self-test, and ease of navigation, no subject responded with a rating below the "Neutral" value of 4. In other words, all items were rated between "Acceptable" and "Completely Acceptable." For those questions where 4 represented the "Just Right" response, such as the amount of information provided and difficulty level, ratings were between 3.5 and 4.5.

Furthermore, responses to questionnaire items correlated well with debrief responses and objective data. For example, the interactive self-test was one of the highest rated items in the questionnaires, with a mean rating of 5.3 on the GRiD task and 6.3 on the ScopeMeter task. During their debriefs, subjects explained that the self-test helped them perform both tasks; however, they found the content of the ScopeMeter self-test to be more helpful than that of the GRiD. Another strong correlation was found with the Cue Card training feature – an abbreviated list of the procedure steps. Especially in the GRiD questionnaire, this item was rated low relative to other training features, although it did indeed receive a rating of "Acceptable." In the objective data collected during training, it is evident that only one subject used the Cue Cards extensively during training.

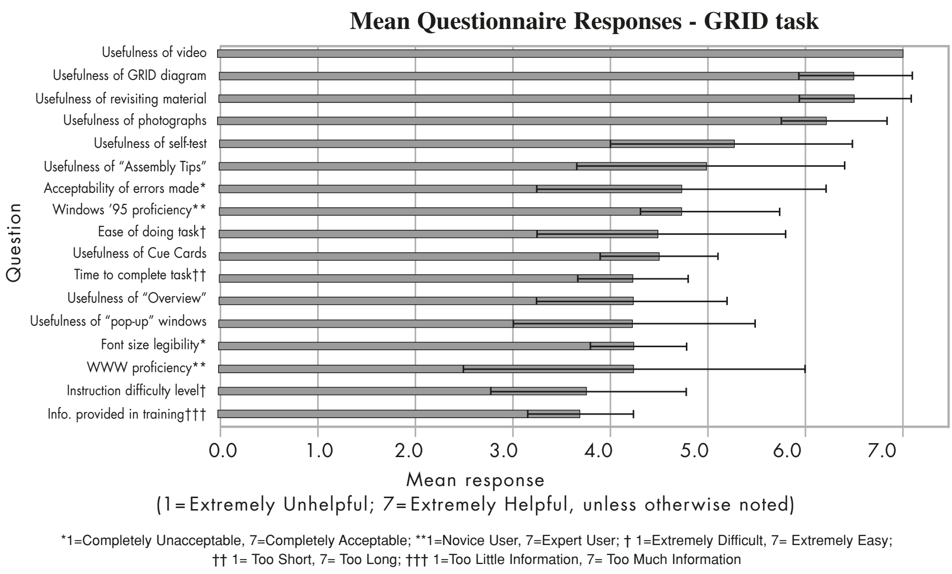


***Figure 6.2-5*** *Mean questionnaire responses for training and performing the GRiD task*

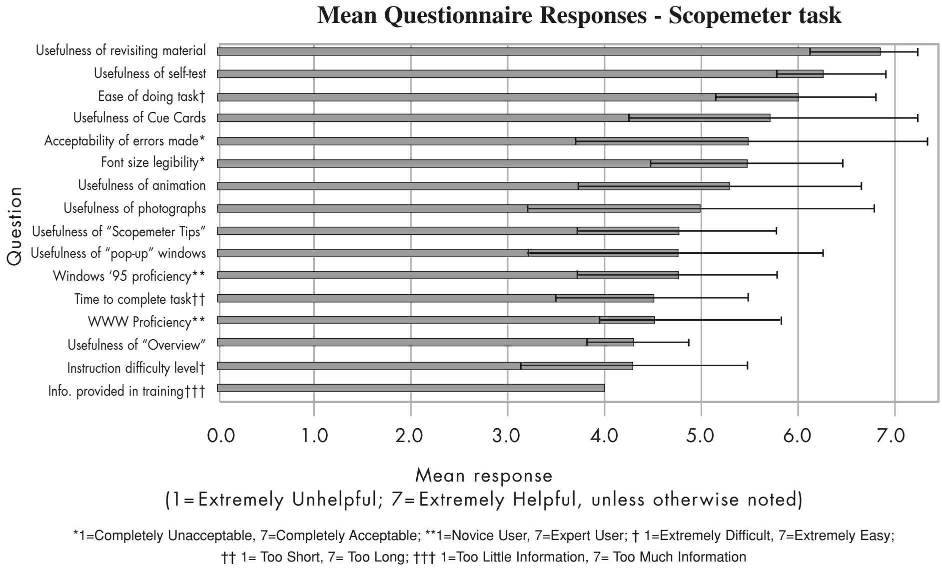


***Figure 6.2-6*** *Mean questionnaire responses for training and performing the ScopeMeter task*

## DISCUSSION

*Conclusions*

When asked if they would prefer a multimedia training tool or real-time audio/video communication for learning various scenarios, most participants would prefer a multimedia training tool with a variety of features that they could have available as a reference. All of the participants felt that the interface was intuitive. They liked the separate windows for the text and the images, so that these features could be accessed simultaneously. A majority of the participants browsed through each of the multimedia features at least once during their training, rather than focusing on one or two features in particular.

Although task performance times did not differ between the MM and Enhanced MM conditions, the participants felt that the inclusion of the self-test improved their knowledge of the task. This is important for use in future training applications so that the crew can monitor how well they have learned a critical task before performing it. For example, exploration missions may have a time lag that is too great for crewmembers to rely on mission control for answers to questions or correction of a mistake; they must decide for themselves when they are ready to perform the task.

Many of the participants reported that the demonstration was well done and was a fun project. One participant commented, "Multimedia is an excellent option for consolidating and standardizing training." Another commented, "Different people learn in different ways and you've covered all the avenues."

Future work will compare these same multimedia training programs with simulation capability, with a virtual reality version of these training programs. The procedures and steps will be the same in both modes, but the simulation in the VR with be truly three-dimensional and the subject will be immersed in the system, rather than using mouse clicks on a flat picture.